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Description

PROCESS FOR REMOVING ADHERENT OXIDE PARTICLES FROM AN ALUMINIZED SURFACE

BACKGROUND OF INVENTION

FIELD OF THE INVENTION

[0001] *[0001]* The present invention generally relates to aluminizing processes. More particularly, this invention relates to a process for removing oxide particles adhered to a surface following aluminizing.

DESCRIPTION OF THE RELATED ART

[0002] *[0002]* The operating environment within a gas turbine engine is both thermally and chemically hostile, particularly within the turbine, combustor and augmentor sections. A common practice is to protect the surfaces of gas turbine engine components with an environmental coating that is resistant to oxidation and hot corrosion, and optionally a thermal barrier coating (TBC) that provides thermal-in-

sulating protection for the component exterior. Environmental coatings that have found wide use include diffusion aluminide coatings and overlay coatings such as MCrAlY. During high temperature exposure in air, these coatings form a protective aluminum oxide (alumina) scale that inhibits oxidation of the coating and the underlying substrate. Diffusion aluminide coatings are particularly useful for providing environmental protection to components equipped with internal cooling passages, such as high pressure turbine blades, because aluminide coatings are able to provide environmental protection without significantly reducing the cross-sections of the cooling passages.

[0003] *[0003]* An aluminizing process capable of selectively coating the internal cooling passages of a turbine blade involves injecting a slurry into the passages. As with other types of processes employed to form aluminide coatings, the slurry aluminizing process relies on aluminiding vapors that react at exposed surfaces to form a diffusion aluminide coating. More particularly, the slurry process makes us of a coating powder comprising a metallic aluminum source (such as aluminum or an aluminum alloy, e.g., CrAl, CoAl, FeAl, and TiAl), a carrier or activator (such

as an alkali metal halide), and an inert oxide dispersant (such as alumina (Al_2O_3) or zirconia (ZrO_2)). These solid particulate components are mixed with an organic or inorganic liquid, whose role is a rheological additive to facilitate the injection of the coating powder into the often complex system of internal cooling passages present in a turbine blade. An example of a suitable inorganic binder is hectorite clay in water, while examples of particularly suitable organic binders include acrylics such as polymethylmethacrylate (PMMA), butyl methacrylate resin, ethyl methacrylate resin, methyl methacrylate resin and methacrylate co-polymer resin. Other organic binders that may be used include methyl cellulose, acrylic lacquer, alkyd resins such as phenolic-modified alkyd and phenolic-modified soybean alkyd, shellac, rosin, rosin derivatives, ester gum, vinyls, styrenics, polyesters, epoxides, polyurethanes, cellulose derivatives, and mixtures thereof. Once the mixture is injected, the liquid is removed by drying, after which the component containing the dried coating media is heated in an inert or reducing atmosphere to a temperature of 1700°F (about 930°C) or more. At the elevated temperature, the activator vaporizes and reacts with the aluminum source to form a volatile alu-

minum halide, which then reacts at the surfaces of the passages to form the aluminide coating.

[0004] *[0004]* Following aluminiding, remnants of the solid components of the slurry must be removed so as not to inhibit the flow of cooling air through the passages. In practice, there is a tendency for particles of the aluminum source to oxidize and sinter to the aluminized surfaces as a result of the high temperatures sustained during the aluminiding process. In that these adherent particles are sintered to the aluminized surfaces, they have proven to be very difficult to remove. Mechanical cleaning techniques such as high-pressure water jets and flushing have been used with limited success. Other approaches that employ caustic compounds at high temperatures and pressures (e.g., performed in an autoclave) to strip TBC from exterior surfaces or remove dirt and contamination from internal passages of gas turbine engine components are undesirable in view of the cost of autoclaving operations. Therefore, in order to maximize air flow through aluminized cooling passages of an air-cooled component, a need exists for a reliable method of removing adherent sintered oxide particles.

SUMMARY OF INVENTION

[0005] *[0005]* The present invention provides a process for removing particles that become adherently sintered to an aluminized surface during an aluminiding process. An important example is the internal cooling passages of gas turbine engine components, such as components within the turbine, combustor or augmentor sections of a gas turbine engine. The method is particularly suited for the removal of oxidized particles that form as a result of oxidation of the aluminum source powder used in slurry aluminiding processes, wherein the oxidized powder particles become attached by sintering to the aluminized surface. The method also serves to remove other particles that may be sintered to the aluminized surface following the aluminiding process, such as oxide particles that were mixed with the aluminum source powder as an inert dispersant. The processing steps of this invention include contacting the aluminized surface with an aqueous caustic hydroxide solution until these adherent particles are removed therefrom.

[0006] *[0006]* According to the invention, an aqueous potassium hydroxide solution at moderate elevated temperatures and atmospheric pressures (i.e., without autoclaving) has been shown to facilitate removal of adherent residual

coating materials, particularly if accompanied by agitation with ultrasonic energy. In this manner, adherent oxidized and oxide particles can be completely removed from the aluminized surfaces of an internal cavity, such as the internal cooling passages of a gas turbine engine component so that cooling air flow through the passages is not reduced. Finally, aqueous caustic hydroxide solutions of this invention are compatible with aluminide coatings, so as not to attack such coatings during removal of the adherent oxide particles.

[0007] *[0007]* Other objects and advantages of this invention will be better appreciated from the following detailed description.

DETAILED DESCRIPTION

[0008] *[0008]* The present invention is directed to the removal of particles that form by oxidation of metal particles contacting a surface undergoing aluminizing, such that the particles adhere to the aluminized surface through a sintering mechanism. As such, the particles of concern to this invention are distinguishable from dirt and contaminants that collect within internal cooling passages of air-cooled gas turbine engine components during engine operation. Furthermore, the particles are distinguishable

from ceramic coatings formed of metal oxides that are deposited as thermal barrier coatings (TBC) on gas turbine engine components. While the advantages of this invention will be described with reference to turbine blades, the teachings of this invention are generally applicable to any component having internal surfaces that benefit from protection by aluminide coating.

[0009] *[0009]* Notable examples of gas turbine engine components that benefit from the present invention include air-cooled high and low pressure turbine nozzles and blades, shrouds, combustor liners and augmentor. Of particular interest are air-cooled components whose interior surfaces are protected by a diffusion aluminide coating deposited by a non-line-of-sight technique, such as a slurry aluminiding process in which metallic particles of an aluminum source can directly contact the surface being aluminized. At the elevated temperatures necessary to transfer aluminum from the aluminum source to the internal surface being aluminized, particles of the aluminum source may oxidize and subsequently become adhered by sintering to the internal aluminized surface. For example, a slurry aluminiding process that uses particles of a Cr-44Al (wt.%) alloy as the aluminum source can result in the

oxidation of at least the outer surfaces of these particles, resulting in the formation of oxidized particles that adhere to the aluminized surface. An additional source of particles that may sinter to an aluminized surface as a result of an aluminiding process is the oxide particles that are conventionally mixed with aluminum source particles to act as an inert dispersant during the aluminiding process.

[0010] *[0010]* The process of this invention entails treating the aluminized surface with an aqueous caustic hydroxide solution, a suitable example of which contains at least 100 grams/liter of potassium hydroxide (KOH). A more preferred solution contains about 175 to about 225 grams/liter of KOH, with the balance de-ionized water. It is believed that other caustic hydroxides such as sodium hydroxide (NaOH) can be used in combination with or in place of potassium hydroxide in the solution. The internal aluminized surfaces are contacted with the solution at a moderate elevated temperature, such as about 150 to about 190°F (about 66 to about 88°C) and preferably about 160 to about 170°F (about 71 to about 77°C). This operation is carried out to ensure that all internal aluminized surfaces are contacted by the solution, such as by

immersing the entire component in a bath of the solution, and preferably flushing the internal cavities with the solution while the component is immersed to ensure complete filling with the solution. Contact with the solution is preferable maintained for a duration of at least two hours, such as about two to about eight hours and more preferably about four hours. During this step, the solution is preferably agitated with ultrasonic energy. For example, the solution may be held in a commercially-available ultrasonic cleaning tank employing magnetostrictive or piezoelectric transducers. Suitable frequencies are about 20 kHz to about 40 kHz and suitable power levels are about 20 to about 120 watts per gallon (about 80 to about 450 watts per liter) of solution, preferably about 50 to about 100 watts per gallon (about 190 to about 380 watts per liter) of solution. Following treatment with the solution, the component is rinsed and its internal cavities flushed with water for a minimum of about five minutes to remove the solution, after which the component is dried.

[0011] *[0011]* During an investigation leading to this invention, high pressure turbine blades were obtained whose internal cooling passages had been selectively aluminized by a slurry aluminiding technique in which metallic particles of

Cr-44Al were used as the aluminum source material. Visual inspection of the cooling passages showed that particles were adhered to the aluminized internal surfaces. These particles, generally about 10 to about 100 micrometers in diameter, were concluded to have been formed by some of the Cr-44Al particles that had oxidized and become attached to the aluminide coating as a result of sintering at the high temperature (about 970°C) sustained during the aluminizing process. One of the blades was cleaned by submersion, blade tips down, in an aqueous solution containing about 40 to about 50 weight percent KOH for about four hours. The solution was maintained at a temperature of about 170°F (about 77°C), and agitated by ultrasonic energy at a frequency of about 25 kHz and a power level of about 100 watts per gallon (about 380 watts per liter) of solution. On removal from the solution, the internal cavities of the blade were flushed with tap water and dried. Visual inspection of the cavities evidenced that the adherent oxidized particles had been completely removed from the internal cavities of the blade. The cleaning procedure was then repeated on an additional four blades with the same results.

[0012] *[0012]* While the invention has been described in terms of a

particular embodiment, it is apparent that other forms could be adopted by one skilled in the art. Therefore, the scope of the invention is to be limited only by the following claims.